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PROBLEM BASED LEARNING BIOMECHANICS LAB: RUNNING SHOES: FRIEND OR FOE

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INTRODUCTION

The problem based learning (PBL) model of learning inherently provides an environment in which students can practice real world biomedical engineering utilizing cutting edge tools. The independent nature of the model promotes leadership and lifelong learning behaviors because the students are responsible for their learning and progress. The open-endedness of the problems encourages creativity and innovation as the students are allowed to define the direction and scope of the project. Since PBL is a team approach, students will become familiar with diversity of thought but also diversity in learning and problem solving styles. The proposed case will be on a much grander scale than anything the students have previously experienced. The activities will reinforce material from lecture and previous courses as well as teach the problem solving process.

RUNNING SHOES: FRIEND OR FOE

The concept of barefoot running is a hot topic among runners especially with the debut of barefoot/minimalist running shoes like the Vibram fivefingers (Figure 1). The ROTC at East Carolina University recently authorized the use of barefoot/minimalist shoes for the running portion of physical training. The high profile debate and ability to apply these results in the student's life will engage the students in this project.

Class Structure

This project is student driven. The instructor acts as a facilitator to help guide the students in the problem solving process. The instructor may also present "just in time" lectures on topics that will help the students complete the project such as biomechanics, programming languages, experimental design, or statistics. A team size of 4-7 students is recommended. The time of the project is from 4-12 lab sessions dependent on how many components are included.

Figure 1: TrekSport Vibram FiveFingers Running Shoe; Example of minimalist shoes [1].

Problem Statement

Students are given the following problem statement based on a high profile question in running.

Shoes are widely considered the most essential piece of equipment for runners. Popular running magazines and running shoe companies have widely reported that advances in shoe technology have helped runners avoid a variety of ailments, including foot, ankle, knee, and back pain. However, a recent best-selling book has questioned whether running shoes might in fact be causing rather than preventing injuries [2].

Your group is tasked with first identifying a common orthopedic injury in runners that has been associated with the biomechanics of a particular foot strike pattern.

To help form their hypothesis, students will need to research the mechanics of running, running injuries, and effect of shoes and foot strike pattern on running. The students will then test this hypothesis using three experimental approaches; 1) mathematical modeling, 2) mechanical testing, and 3) human subjects testing.

Mathematical Model

Mathematical modeling is often a very abstract approach for students to understand. To help cement the potential of modeling the second two approaches will be used to validate the model. The goal of this approach is to select or develop a mathematical model that is capable of approximating the transfer of force from the foot strike to the injured tissue both with and without shoes present.

Students will need to research previous mathematical models or they may choose to develop their own based on a free body diagram of the foot. This problem can supplement topics in lecture such as applications of statics and mechanics of materials to the body, and modeling of muscles and tendons using electrical components.

The deliverable for this section is a functioning model with defined inputs, model parameters, and output necessary to address the hypothesis. The model can be implemented using such programs as Matlab or Simulink (MathWorks, Natick, MA). This will allow students to use skills they learned in previous courses. Teams will present their model in class. The results from the model will inform the mechanical and human subjects testing.

Mechanical Testing

The goal of this approach is to measure a mechanical property of running shoes (tension, torsion, or compression) required by the mathematical model in order to study the effect of different shoes. Prior to testing teams must submit their testing protocol for approval. Students may find that a rig is necessary to support the shoe during testing. If this is the case, students have access to simple tools and support from lab supervisors. To conduct the experiments students may use the instructional labs equipped with an Instron (Instron, Norwood, MA). This portion will reinforce techniques learning in our Mechanics of Materials lab.

Upon completion of this stage students will have created an experimental protocol, conducted the experiment, and analyzed the results. The results can then be incorporated into the mathematical model for the final report.

Human Subjects Testing

The human subjects testing consists of two parts; a high-cost and low-cost experimental set up. The goal of this approach is for the students to test their hypothesis using human subjects. The high-cost experimental set up is available in the Biomechanics Lab in the College of Health and Human Performance and consists of a high speed motion capture and force plate system. Teams will be able to test one subject with 2-3 shoe types. Each team will determine what measurements they need to test their hypothesis.

The low-cost experimental set up consists of goniometers and force plates (PASCO scientific, Roseville, CA, USA). This human subjects testing portion of the study must be designed to use the number of subjects necessary to produce statistically significant results and to ensure the safety of their subjects. The experimental protocol will be submitted to the ECU Institutional Review Board (IRB) for approval. All members of the team must complete the on-line human subjects training course prior to submission. Upon approval from the IRB the teams can begin testing. This portion of the approach complements lecture discussion of biomedical ethics and the history of human subjects testing. The data from this portion of the experiment will be presented in class.

The Final Report

The final submission for this project is a report in journal article format. The report will include all three approaches. The mathematical model must be fully described and any additions made due to the mechanical testing discussed. Also the model may be validated using data from the literature. The mechanical testing protocol must be reported including the data and data analysis. The experimental protocol for the human subjects testing must be described and all data from both the high-cost and low-cost data collection presented. A discussion of the two data sets and comparison to the mathematical model must be included. This exercise will improve the student's technical writing skills.

IMPLEMENTATION

To date all three approaches have not been implemented in the same course. Portions have been implemented into BIME 4030 Biomechanics and Materials. Students struggled with the mathematical model but were able to incorporate components from models presented in the literature. Students enjoyed designing their own experiments; however they struggled with getting the appropriate number of volunteers. Time management was also an issue for the students who were then rushed to finish data collection and had limited time available for data analysis.

CONCLUSIONS

The PBL case presented incorporates many aspects of a biomechanics class and allows the student to drive the learning process. Optimization is an ongoing process as well as fine tuning the assessment.

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